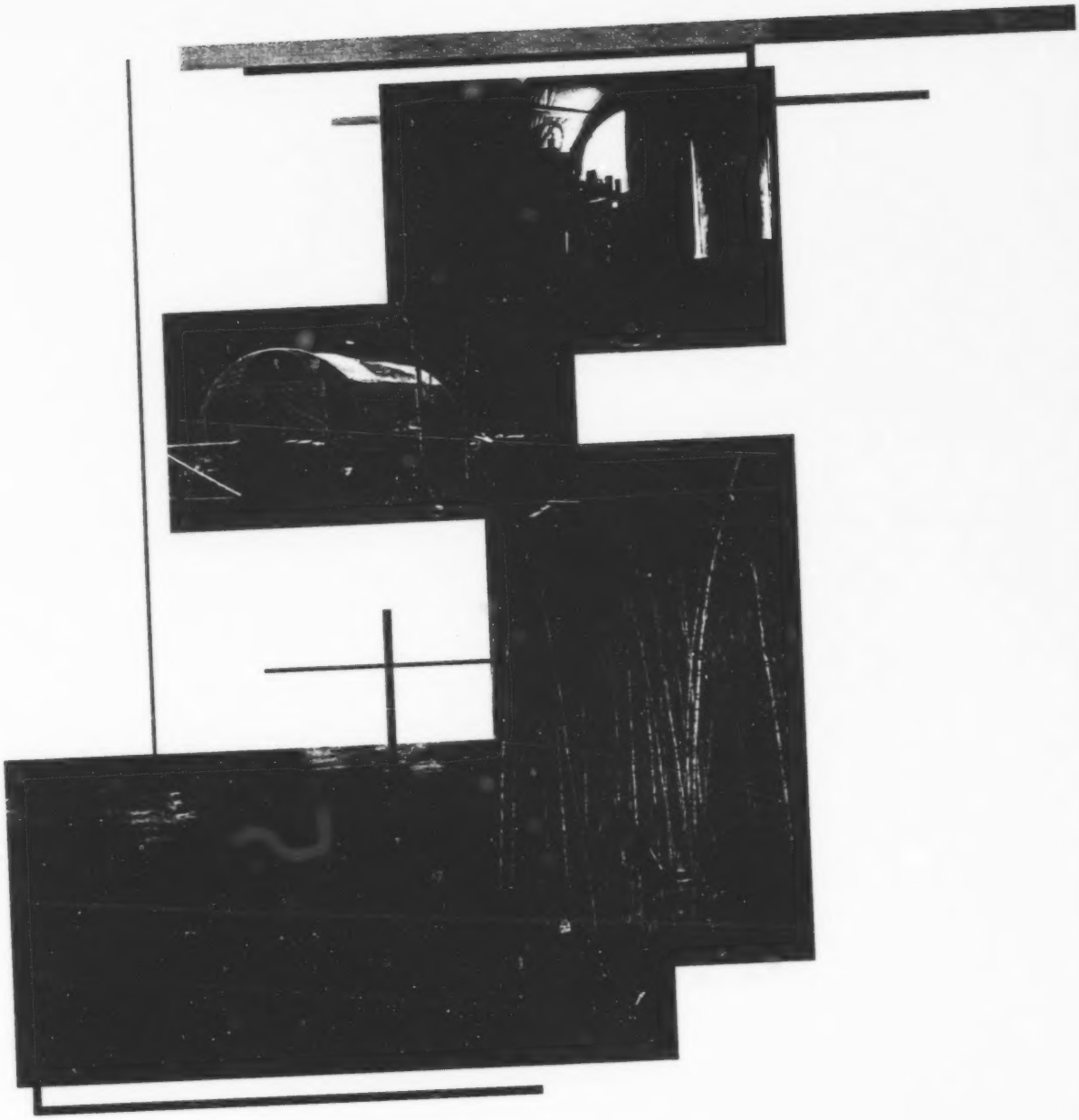
TROLS 2002

Terrestrial and Riparian Organisms, Lakes and Streams

Collaborative Research Project

OVERVIEW FOR PARTNERS
SEPTEMBER 2002

TROLS



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Dedicated to those individuals who embrace multi-sector training and research.

Dedi mbrace

INTRODUCTION

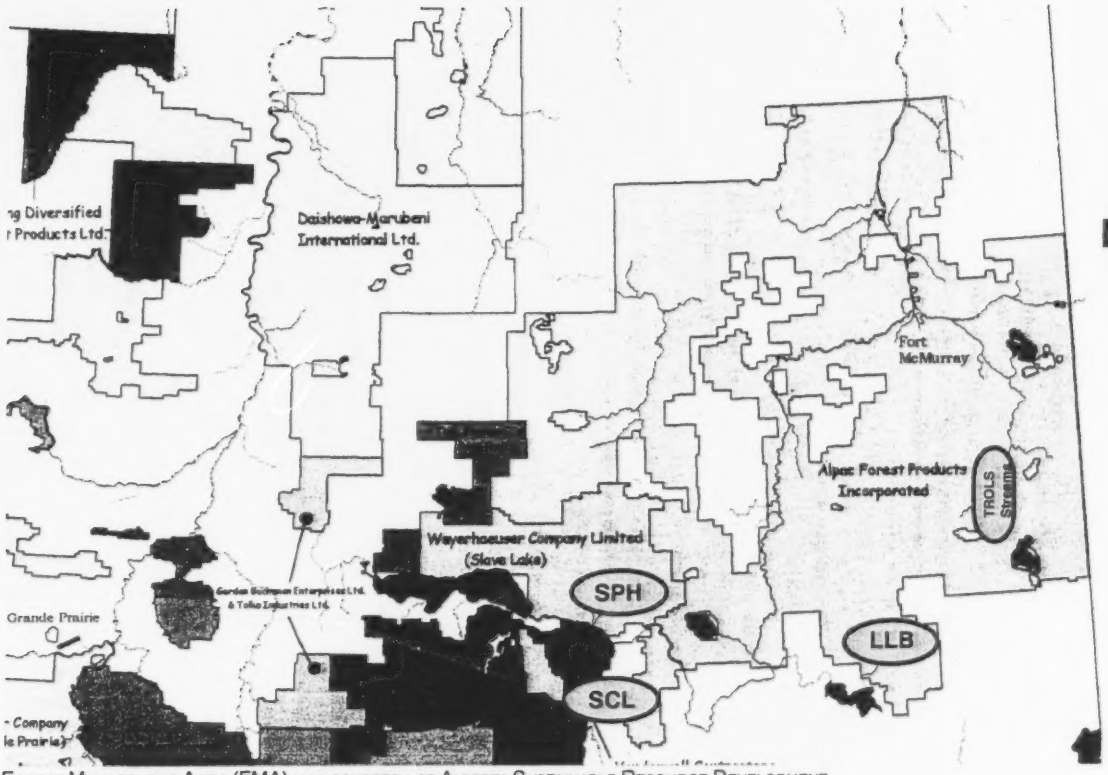
The Terrestrial and Riparian Organisms, Lakes and Streams (TROLS) Project was a collaborative research effort that linked interested parties within the private and public sectors from 1994 to 2000. Over this six-year period, the TROLS Project initiated research on the impacts of forested buffers and their practical application to preserving the integrity of aquatic and terrestrial communities in the boreal (mixed-wood) forests of western Canada.

Prior to the TROLS Project, minimal information existed on appropriate widths for forested buffers within the mixed-wood forest in Alberta. The guidelines for placement of buffers in harvesting plans were based on those in existence in other provinces. It was unknown whether such management systems would accommodate the unique features of Alberta's northern forests. This project was undertaken to assess the roles forested riparian buffers play in a sustainable mixed-wood forest system in this region.

Through the efforts of research staff and students, and from close associations with industry and government partners, the TROLS Project completed its sixth and final year of research in spring 2000. Work then commenced to integrate and analyze the vast database that had been assembled. Results and implications from some of the primary study areas are presented here.

Watercourse Classification	Watercourse Protective Buffer
Large permanent flowing waters	60 m
Small permanent flowing waters	30 m
Intermittent	Buffer of brush and lesser vegetation; treed buffer not required unless requested by Forest Officer
Ephemeral	Buffer of lesser vegetation in wet gullies left undisturbed
Lakes (little or no potential for recreation waterfowl or sportfishing)	> 16 ha, no harvest within 100 m unless approved
Lakes (potential for recreation, waterfowl or sportfishing)	> 4 ha, no harvest within 100 m unless approved
Water source areas and areas subject to normal flooding (*eg.* wetlands)	Treed buffers of at least 20 m on all streams with no harvest unless approved

SUMMARY OF 1994 BUFFER STRIP REGULATIONS FROM ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT



FOREST MANAGEMENT AREA (FMA) MAP COURTESY OF ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT

PROJECT DESIGN

Twelve ground accessible, fish bearing study lakes were chosen from three geographic regions: Lac La Biche, South Pelican Hills and South Calling Lake. Lakes were labelled to reflect study area and buffer width treatment. For example, LLB20 was situated in the Lac La Biche study area and had a 20-m buffer treatment. Unharvested, aspen-dominated forest more than 50 years of age extended at least 800 m from the edge of each lake selected. In addition, lakes were selected that had a surface area of less than 200 ha, and maximum depth was greater than 2 m. Eleven[1] of the twelve lakes were headwater lakes.

Five study streams were located south of the Stoney Mountains between Anzac and Chard, Alberta: Meadow Creek, Cottonwood Creek, Kettle River, Pony River and Waddell Creek. Streams were permanent, non-headwater (primarily 3rd order) systems that drained landscapes dominated by conifers and wetlands, interspersed with merchantable aspen stands. Some upper stream sites were inaccessible by ground and had to be sampled by helicopter.

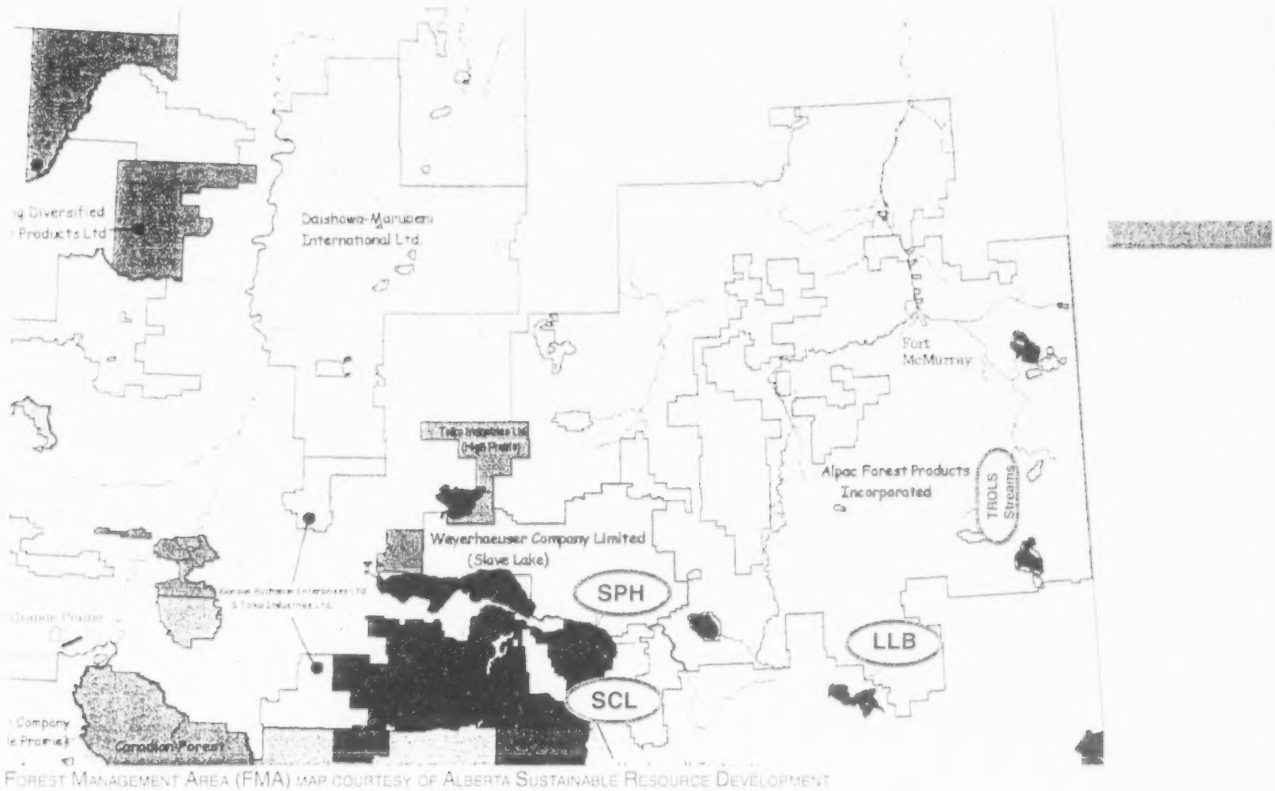
[1]TROLS lake SCL200 was not included in some analyses due to its essentially riverine qualities (*i.e.*, extremely short water residence time) and position in the landscape as a non-headwater lake.

Following site selection, the TROLS Project was divided into two time periods: pre-harvest and post-harvest. During the two-year pre-harvest stage, the project sought to establish baseline conditions for terrestrial, aquatic and hydrological regimes. This included factors such as:

- flora
- fauna
- water quantity and quality
- weather
- soils

The beginning of the post-harvest stage was marked by forest harvesting during the winter of 1996 to 1997. Riparian forested buffers were left unharvested in widths ranging from approximately 20 to 200 m from the water's edge surrounding the lakes. Regions with unharvested buffers of 800 m or more were used as control areas for the lakes. For streams, two reaches per stream were selected, with a 30-m buffer along the upper reach and a 0-m buffer along the lower reach. Sample sites just above the upstream limits of the 30-m buffer reach were used as control areas. Following harvest, buffer treatment effects on the terrestrial, aquatic and hydrological conditions of the study lakes and streams were evaluated for three years.

Within the 800m buffer, control lakes were protected only from forestry impacts



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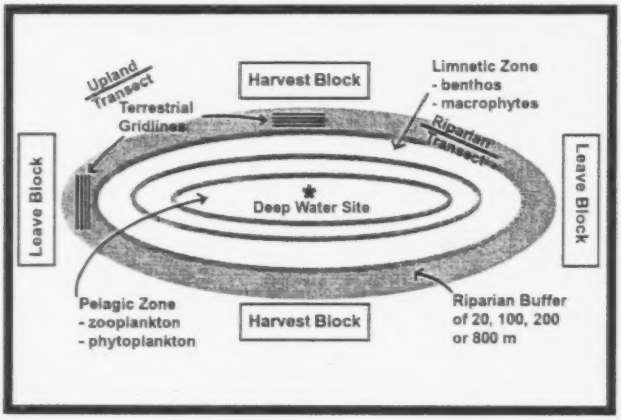
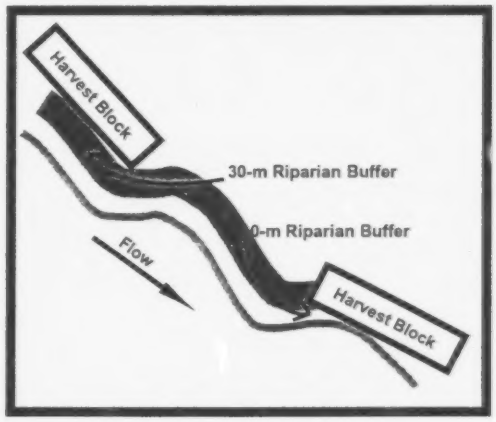
Layout and Challenges

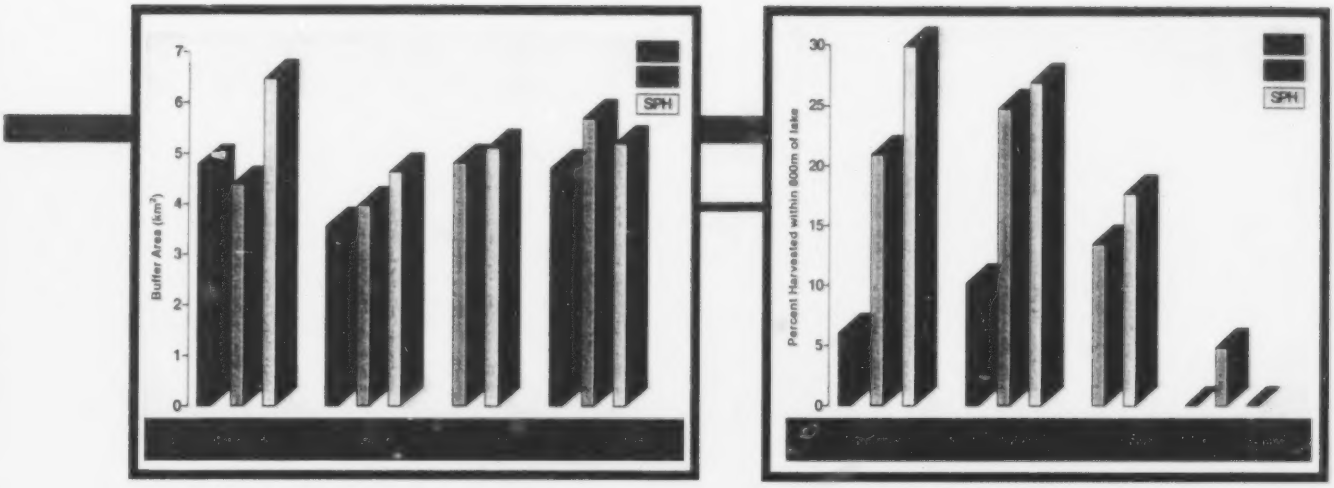
The bulk of sampling occurred from late spring to early autumn each year, although sampling was conducted throughout the winter months for water quality, mammal tracking, and snow surveys. Small mammals, songbirds and amphibians were studied within two **leave** and two **harvest** grids located at each lake (in the 800-m treatment lake, the grids were all labelled reference grids). Leave grids were placed in the buffer zones next to uncut forest, whereas harvest grids were located in the buffers adjacent to cut areas. Lines within each grid paralleled the lakeshore, beginning in the non-forested transition zone and spaced at 25-m intervals extending into the upland forest (at the 20-m lakes, the first gridline was at 20 m, not 25 m). Vegetation sampling took place along two transects parallel to lakeshore at each lake: one in the riparian zone, and one in upland forest. Within lakes, deep-water sites were marked each spring where the bulk of water quality sampling took place, augmented with random sampling at satellite locations. Lake sampling locations for other parameters were dictated by sample type. Stream sampling took place at the upper and lower limits of each of the two reaches per stream. The bulk of hydrological sampling occurred in one principal catchment in the northeast corner of LLB20.



Lake Layout



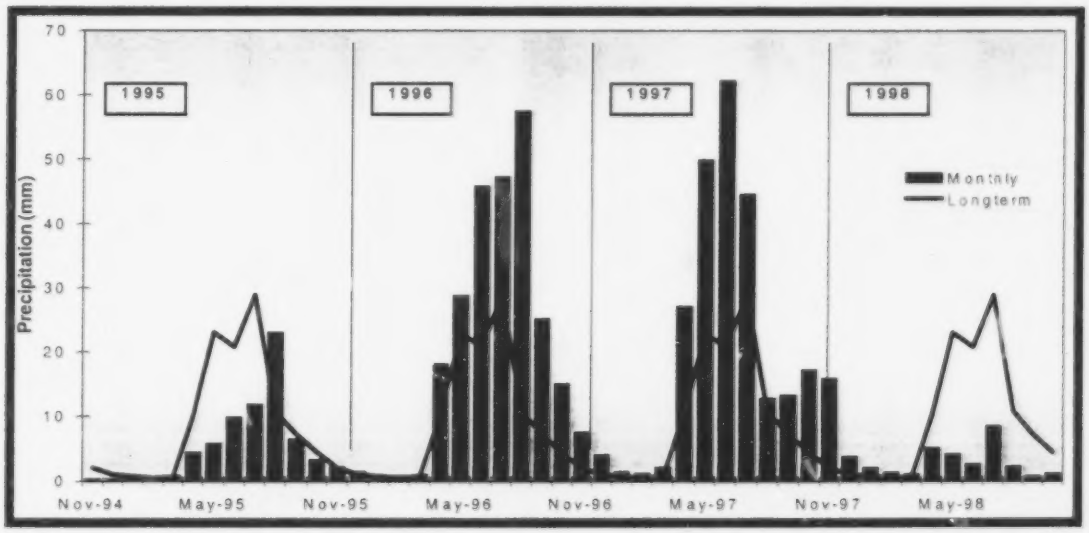
Stream Layout



BUFFER AREA (KM²) PER TREATMENT LAKE

AMOUNT HARVESTED (%) PER TREATMENT LAKE

Coordination of efforts on such a large-scale design was a project in itself, and weather was a major challenge. The 1995 sampling season marked the end of a drought cycle, followed by two of the wettest, then two of the driest years in a 30-year period. Forest harvesting volumes were also a concern. Harvest amounts at both SCL20 and SCL100 were lower compared to the same treatment levels in the other two regions, and accidental harvesting occurred within the reference buffer at LLB800. Cooperation, tolerance and flexibility were instrumental in offsetting these obstacles and making the TROLS Project a success.



MONTLHY RAINFALL BASED ON A NOV-OCT WATER YEAR; LONGTERM MEAN FROM 30-YEAR NORMALS FOR THE STUDY REGIONS

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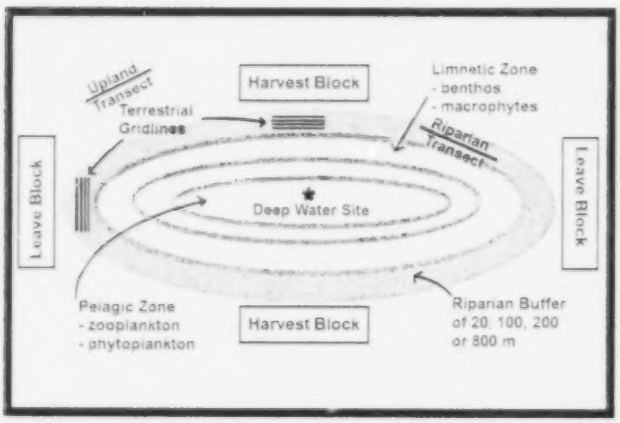
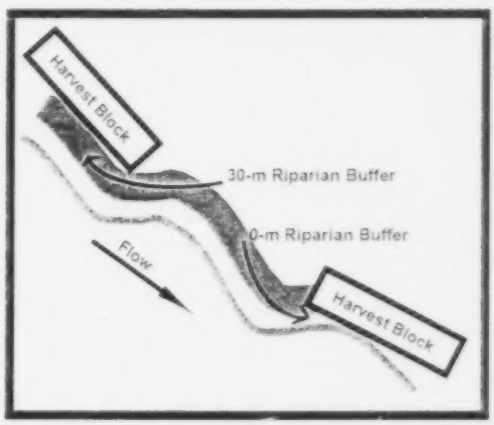


Lake Layout



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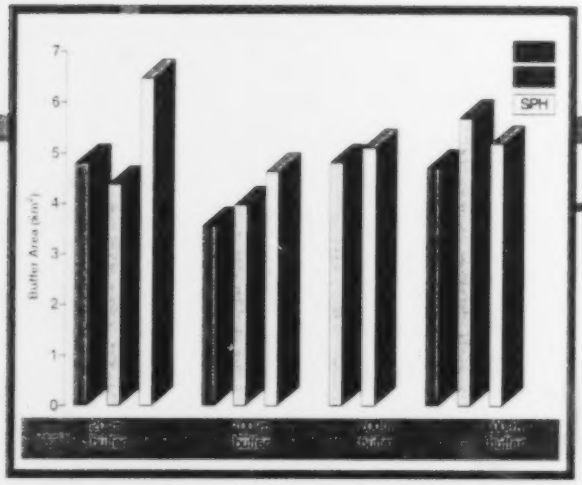

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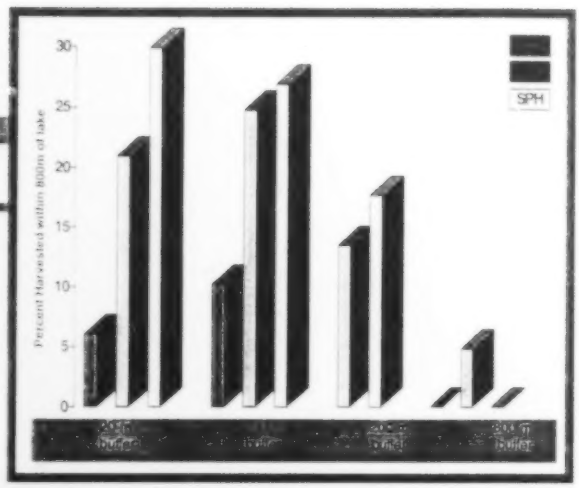

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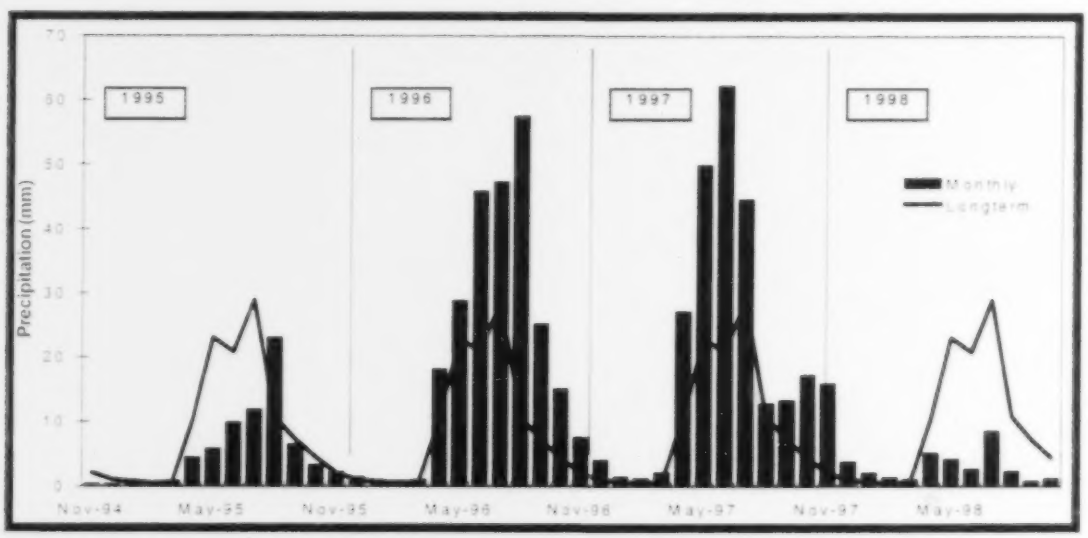


MONTLHY RAINFALL BASED ON A NOV-OCT WATER YEAR; LONGTERM MEAN FROM 30-YEAR NORMALS FOR THE STUDY REGIONS

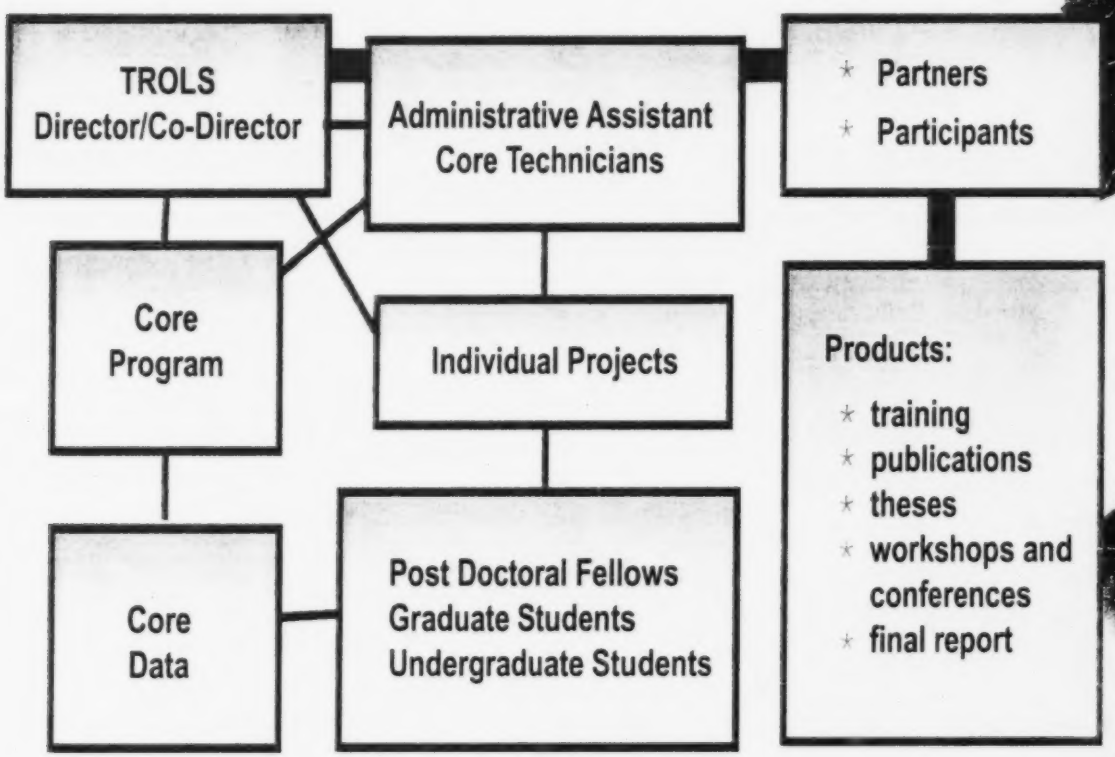
PROJECT OBJECTIVES

Five primary objectives formed the central focus of the research project. TROLS sought to understand and provide recommendations on:

- ***the ecological function of riparian forests***
- ***the ability of riparian forests to conserve plant and animal populations and buffer water bodies***
- ***the connections between terrestrial and aquatic ecosystems***
- ***the impact of forest harvesting and forested buffers of varying widths on aquatic systems***
- ***an appropriate approach to buffer management as a contribution to sustainable forestry***

A sixth objective of the project was to serve as a teaching tool. The TROLS project allowed students to be trained in an environment where they were exposed to a wide spectrum of academic disciplines. Opportunities for cooperation with partners were many, including individual project design input, presentations, and interactions during workshops. Field sampling skills and data management abilities were heavily emphasized. More than 125 graduate and undergraduate students were educated and trained during the course of the TROLS Project.

TROLS PROJECT ORGANIZATION



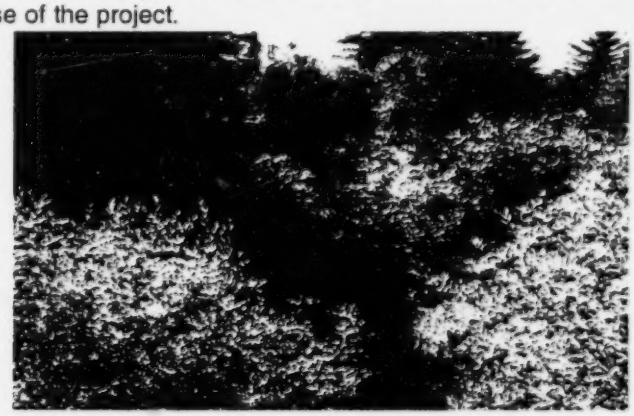
IMPACTS

...On Land

Measurements of forest structure and composition revealed slight differences between riparian and upland forests. However, the differences were small at the stand level and even smaller at coarser resolutions. This suggests that in the study area, variations in forest structure were not strongly influenced by distance from surface water. The composition of understorey vegetation often varied significantly between riparian zone versus upland forest constituents. The overstorey, however, did not show this trend nearly as strongly.

The effects of edge, both natural and created, were detected approximately 40 m into the remaining forest. Thus, in a 100-m buffer strip with one lakeshore edge and one harvest block edge, a band approximately 20 m wide existed centrally that exhibited no edge effects. It is predicted that these effects will continue for at least 15 years, despite the rapid regeneration of adjacent harvest blocks. In addition to being entirely edge habitat, the 20-m buffer strips also experienced significant blowdown. Buffer strips need to exceed 100 m to both decrease blowdown losses and moderate edge effects.

Many of the vertebrate species monitored during the study proved to be habitat generalists. Variations in buffer width did not have a noticeable impact on either small mammal or amphibian communities, since they were relatively abundant in both cut and uncut areas. However, crowding was evident with bird species in the 20-m buffer strips during the first year following harvesting. Although total bird abundance did not differ between the pre- and post-harvest periods, species diversity decreased in the 20-m and 100-m buffer strips. Overall, buffers of 20 to 100 m did not function as adequate reserves for forest dependent bird species, whereas the 200-m buffers were effective in this regard over the course of the project.



IMPACTS

...*Subsurface*

The hydrogeological processes underlying Alberta's northern forests are highly complex. Lithology consists mainly of nutrient rich organic matter over deep layers of fine mineral soil comprised of sand and clay glacial till. Aspects of the TROLS Project sought to describe:

- § where subsurface flowpaths were occurring
- § if and how harvesting increased nutrient (primarily phosphorus) inputs into surface waters
- § phosphorus and nitrogen mobilization and transport in boreal mixedwood soils

Total dissolved phosphorus (TDP) concentrations were examined in shallow, subsurface flow from cut and uncut subcatchments. Differences detected in TDP concentrations between cut and uncut regions were related more to local hydrology than to direct harvesting effects. When present, sand lenses in the glacial till tended to re-route overland flow to subsurface paths, bypassing the ameliorating effects of buffer strips both above ground and within the fine root zone.

Soil nitrogen species were also quantified for cut and uncut regions of upland forests. The first growing season following harvest saw no significant difference between cut and uncut plots in two aspen dominated stands. However, in an aspen-conifer mixed stand, nitrification rates were higher in cut versus uncut plots over the same time period. Thus, in cut plots more nitrogen existed as nitrate, which is highly water soluble and susceptible to leaching. Increased nitrogen mobilization and loss from soils with particular canopy characteristics may occur after forest harvesting.

Measurements of saturated hydraulic conductivity indicated that logging decreased infiltration rates post-harvest relative to forest soils with unharvested canopies. Differences reflected a decrease in macro-porosity in upper soil horizons related to logging-induced compaction and soil swelling following harvest, in spite of harvesting occurring on frozen soil. Thus, increased runoff is more likely to occur in harvested areas where mineral horizons are exposed.

IMPACTS

...In Water

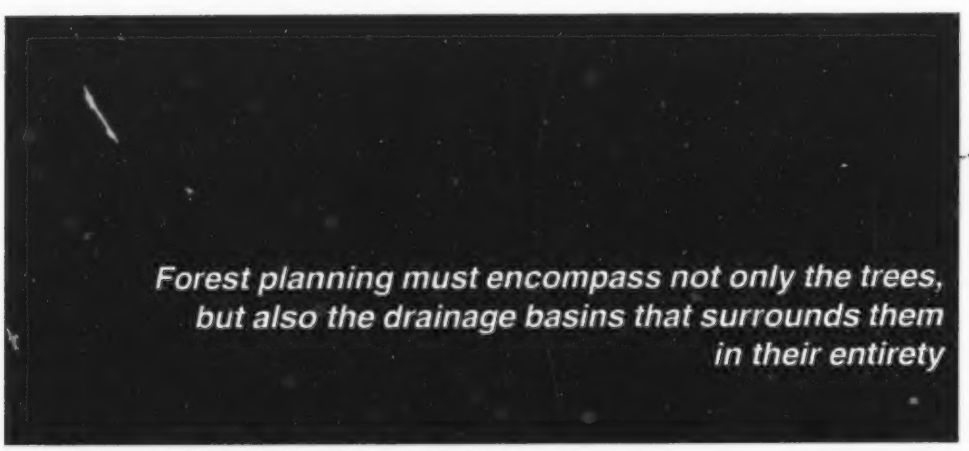
Eleven[1] of the TROLS lakes were evaluated for nutrient and plankton responses during the study. During the first post-harvest sampling year, an increase in total phosphorus (TP) concentrations was strongest in those study lakes that were shallow, with consistently mixed or only weakly thermally stratified water columns. Related to the phosphorus increases, concentrations of chlorophyll *a* (an indicator of phytoplankton biomass) and cyanobacteria (as well as resulting cyanotoxins) also increased post-harvest, primarily in the shallow lakes. This was supported by a positive relationship between littoral surface area and whole-lake photosynthesis rates. Although phytoplankton biomass increased, species composition shifted towards forms less edible to zooplankton. Individual zooplankton size and overall biomass decreased post-harvest as a response to diminished food quality, especially in shallow, unstratified lakes where the amount of edible phytoplankton declined.

Post-harvest changes in TP concentrations were most strongly related to weather and watershed characteristics, especially relative watershed size[2] ($r^2 = 0.78$, $P < 0.01$). In the two-year sampling period following harvest, TP concentrations increased proportional to relative watershed sizes. High rainfall events accelerated nutrient transport and increased surface runoff and connectivity between wetlands, lakes and streams. Lake position in the landscape accounted for a smaller overall portion of the variation ($R^2 = 0.42$, $P = 0.03$) than was reported with preliminary data[3], especially when compared with relative watershed size as a predictor. Data did not indicate that buffer strip width had any mitigating effects on in-lake responses; lakes with the largest buffers had the strongest post-harvest nutrient response. Rather, the results indicate the activities within the entire watershed and the structure of the lakes themselves should be considered when examining catchment-lake interactions.

[2]relative watershed size = drainage basin area / lake volume (after Prepas *et. al*, 2001)
[3]Devito *et. al*, 2000

IMPLICATIONS

The TROLS Project demonstrated that watershed characteristics, landscape features and the physical attributes of *individual systems* affect response to harvesting. Riparian forests of the boreal mixed-wood region were discovered to play a less obvious role in buffering aquatic systems and maintaining some of the vertebrate populations examined. The complexity of dealing with watersheds and habitat at a landscape scale requires a major shift in focus away from prescriptive planning around solely Forest Management Area (FMA) boundaries. Suggestions for beginning to address this complexity can be grouped into aquatic and terrestrial components based on project results.



IMPLICATIONS

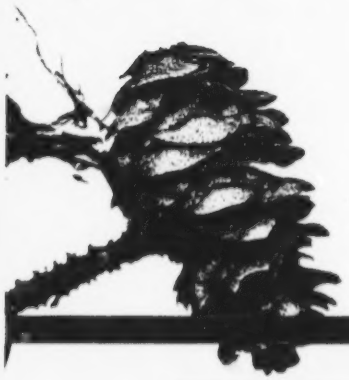
From a terrestrial standpoint:

Riparian buffer strips played no detectable role in maintaining small mammal and amphibian populations, although pre-harvest songbird communities were preserved in strips of 200 m or more.

Terrestrial Factor	Management Implication
Buffer strips 100m or less are ineffective in reducing edge effects and are more susceptible to blowdown as buffer width decreases	Leave larger, continuous areas of forests unharvested to moderate edge effect and reduce loss of cover due to blowdown
Buffer strips 200 m or less are ineffective in preserving territory for vertebrates that operate on a much larger and wider ranging scale than those examined	Propose longer rotation times on some blocks to maintain species (*e.g.* raptors, woodpeckers, mammalian carnivores) dependent on larger, continuous forests with old growth characteristics

Areas for further terrestrial research:

- determine appropriate patterns for leave areas to maintain old growth forested habitat
- shift scale of study from short-term to full block rotation time to incorporate more cumulative effects
- extend parameters to accommodate more variation in canopy cover



IMPLICATIONS

From an aquatic standpoint:

There is no evidence that vegetated buffer strips along aquatic systems play a detectable role in maintaining water quality and aquatic bioindicators.

Aquatic Factor	Management Implication
Key indicators (TP, cyanobacteria) of water quality increase in response to watershed disturbance	Include routine water sampling for at least primary indicators and maintain a geographically linked chemical database
Shallow boreal lakes situated in flat landscapes that have large drainage ratios[4] (> 4) are at most risk	Identify potentially sensitive watersheds within FMAs; wood volumes and block rotations may need to be tailored to the level of sensitivity

Areas for further aquatic research:

- refine the relationship between watershed disturbance and water quality indicators to improve predictive power
- quantify risks associated with all watershed disturbances
- examine modelling capabilities for linking aquatic indicators with Detailed Forest Management Plan (DFMP) components

[4]drainage ratio = watershed area / lake surface area (after Carignan and Steedman, 2000)

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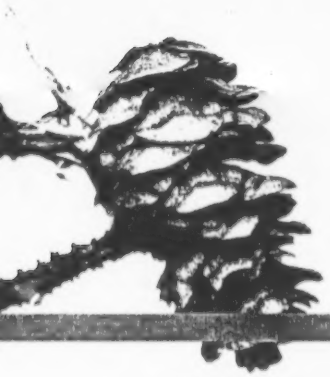

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The TROLS Project garnered its strength from the many people that shared in its development, maintenance and completion. Students and staff survived rustic accommodations, inclement weather, wildlife, plant life, and off-road travel to produce a wealth of scientific information and experience.

STAFF

The Project benefited from a core complement of permanent staff members. Each member acted as a coordinator for specific research components and was required to interact with principal investigators, research partners, and summer assistants. As well, coordinators assisted with collecting data, maintaining individual databases, writing, and general troubleshooting.

Mr. Mark Serediak	*Project Administrator* (1994 - 2001)
Mr. Warren Zyla	*Logistics Coordinator* (1994 - 2001)
Ms. Elena Klein	*Terrestrial Coordinator* (1994 - 1996)
Mr. Andrew McAllister	*Terrestrial Coordinator* (1996 - 1997)
Mr. Matthew Wheatley	*Terrestrial Coordinator* (1997 - 2000)
Ms. Johanna Pierre	*Terrestrial Coordinator* (2001)
Ms. Sharon Reedyk	*Aquatic Coordinator* (1994 - 1997)
Mr. Kelly Field	*Aquatic Coordinator* (1994 - 1995)
Ms. Nancy Scott	*Aquatic Coordinator* (1997 - 1999)
Ms. Nadia Carmosini	*Aquatic Coordinator* (1999 - 2001)

Many research associates also provided their time and expertise to the TROLS Project:

Dr. Uldis Silins, University of Alberta	Site selection and baseline analyses
Mrs. Gertie Hutchinson, University of Alberta	Water analyses and student training
Ms. Roseline Rudy, University of Alberta	Water analyses and student training
Ms. Ginette Méthot, Université de Montréal	Zooplankton sorting and analyses
Mr. Serge Paquette, Université du Québec à Montréal	Phytoplankton sorting and analyses
Ms. Mary Ferguson, National Water Research Institute	Stream sampling and logistics

The Meanook Biological Research Station (MBRS) provided an invaluable service to TROLS as a base of operations for field work, equipment storage and maintenance, and provision of sample analyses. We gratefully acknowledge the notable contributions of the two MBRS Station Managers, Ms. Kathleen Gibson and Ms. Kathryn Murie, to TROLS.

STUDENTS

TROLS introduced many students to the rigors of fieldwork in northern forests. Some continue to analyze the immense data collected throughout the project. Of those who have completed their theses, some have moved into the workforce while others pursue further education.

Student advancements

Mr. Chris Applewhaite is currently employed as a Warden with Parks Canada in Waterton National Park.
Ms. Nicole Armstrong is currently employed at Manitoba Conservation as a water quality specialist.
Ms. Catherine Beaudoin is continuing her studies in Environmental Law at Dalhousie University, and has also provided continued writing assistance to the TROLS project.
Mr. Carl Burgess is an ecosystem planner with Indian and Northern Affairs Canada in Whitehorse, Yukon Territory.
Ms. Nadia Carmosini was employed with the TROLS project as Aquatic Coordinator before relocating to Purdue University to pursue a Ph.D degree.
Mr. Andrew Danylchuk is currently a member of the resident faculty at Boston University's School for Field Studies Centre for Marine Resource Studies, Turks & Caicos Islands, British West Indies, while completing his Ph.D. thesis.
Ms. Christine Decker works as a Technologist at Alberta Environment, Natural Resource Services.
Mr. Jordan DeGroot is employed as a Habitat Biologist with the Department of Fisheries and Oceans in Iqualiut, Nunavut Territory.
Mr. Geoff Eerkes is pursuing a M.Sc. degree at the University of Waterloo.
Ms. Jeanette Evans has travelled the world since graduation and most recently held a lecturer position at the University College of the Cariboo.
Dr. Anas Ghadouani is pursuing his research interests as a Post Doctoral Fellow at the University of Waterloo.
Dr. Karen Harper is continuing her research as a Post Doctoral Fellow at Université du Québec **à** Montréal.
Mr. J. Daniel Lambert is employed as a Conservation Biologist with the Vermont Institute of Natural Science where he heads the Conservation Biology Department's citizen science program and chairs the Vermont Loon Recovery Project's steering committee.
Mr. Peter Langlois is currently employed as a biologist with Habitat Works, an environmental consulting firm in Toronto, Ontario.
Ms. Stéphanie Nicopoulos is continuing her research into the Ph.D. level at the Université de Franche-Comte, France.
Ms. Susan Peters is employed as a Research Assistant with the Department of Renewable Resources at the University of Alberta.
Dr. Johanna Pierre is continuing her research as a Post Doctoral Fellow at the University of Tokyo.
Ms. Susan Tiege is employed as a fisheries officer with the Department of Fisheries and Oceans in Edmonton, Alberta.
Ms. Leah Turner is pursuing a degree in Veterinary Medicine at the University of Sakatchewan.
Ms. Mary Veliz is employed as a Biologist with the Ausable Bayfield Conservation Authority working to compile watershed data for the Ausable Bayfield area in Ontario.

ACHIEVEMENTS

Completed Theses

Armstrong, N. 2000. Contribution of littoral and pelagic algal photosynthesis in Boreal Plain lakes. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisors: Prepas, Ellie E.; Planas, Dolors.

Beaudoin, C. 1998. Stable isotope study of food webs in lakes of Alberta's boreal forest. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisors: Tonn, William M.; Prepas Ellie E.

Burgess, C. 1997. Forested landscape patterns in the western boreal mixedwood forest of Alberta: Riparian Forests, Fire History, Canopy Composition and Topography. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisors: Boutin, Stan; Macdonald, S. Ellen.

Carmosini, N. 2000. Net and gross nitrogen mineralization and nitrification in upland stands of the mixedwood boreal forest following harvesting. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisors: Prepas, Ellie E.; Devito, Kevin J.

DeGroot, J. 2001. Riparian corridor use by ungulates and mammalian predators. Department of Biological Sciences, University of Alberta. M.Sc.thesis. Supervisors: Boutin, Stan; Macdonald, S. Ellen.

Evans, J.E. 1999. Dissolved phosphorus in shallow subsurface water in an uncut and cut subcatchment of a lake on the Boreal Plain. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisors: Prepas, Ellie E.; Devito, Kevin J.

Ghadouani, A. 2002. Interactions écologiques et toxicologiques entre le zooplancton et le phytoplancton dans
les lacs eutrophes. Ph.D. thesis. Supervisors: Pinel-Alloul, Bernadette; Prepas, Ellie E.

Harper, K. 1999. Forest structure and composition at natural and created edges in the boreal mixedwood. Department of Renewable Resources, University of Alberta. Ph.D. thesis. Supervisor: Macdonald, S. Ellen.

Lambert, J.D. 1998. Ovenbirds (*Seiurus aurocapillus*) in riparian buffer strips: short-term response to upland timber harvest in Alberta's boreal mixed-wood forest. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisor: Hannon, Susan A.

Langlois, P. 2000. The influence of trophic state, thermal structure and winterkill on littoral macroinvertebrate communities in Boreal Plain lakes. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisor: Prepas, Ellie E.

Nicopoulos, S. 2001. La biomasse et la biodiversité des épiphytes en fonction du niveau trophique des lacs et des espèces de macrophytes. M.Sc. thesis. Supervisors: Planas, Dolors; Prepas, Ellie.E.

Peters, S. 2000. The impact of small mammals on natural regeneration of white spruce after logging. Department of Biological Sciences, University of Alberta. M.Sc. thesis. Supervisors: Boutin, Stan; Macdonald, S. Ellen.

Pierre, J. 2001. Effects of forest harvesting disturbance on aquatic birds in the boreal forest of Alberta. Department of Biological Sciences, University of Alberta. Ph.D. thesis. Supervisor: Paszkowski, Cynthia A.

Veliz, M. 1999. Relationship of nutrients and mayfly (Ephemeroptera) abundance and diet to periphyton biomass in boreal streams. Department of Biological Sciences, University of Alberta, M.Sc. thesis. Supervisors: Culp, Joseph M.; Chambers, Patricia A.; Prepas, Ellie E.

Continuing Student Theses

Bouffard, C. M.Sc. candidate. Impacts de différentes pratiques de coupe forestière sur le zooplancton des lacs de l' Alberta. Completion date: Dec. 2002. Supervisor: Pinel-Alloul, Bernadette.

Danylchuk, A. Ph.D. candidate. Factors regulating population structure and life history characteristics of fathead minnows in boreal Alberta lakes: the role of intraspecific interactions and the effects of forest harvesting. Completion date: Dec. 2002. Supervisor: Tonn, William M.

Eaton, B. Ph.D. candidate. Effects of forest clearing on wood frog population dynamics. Completion date: Dec. 2002. Supervisor: Paszkowski, Cynthia A.

Kalef, N. M.Sc. candidate. Influence of valley wetlands in nutrient export from forest following clear-cut in the western boreal forest. Completion date: Oct. 2002. Supervisor: Devito, Kevin J.

Presant, P. M.Sc. candidate. Effects of natural and created edges on forest microclimate and soil nutrient and water relations. Completion date: 2002. Supervisor: Macdonald, S. Ellen.

Whitson, I. Ph.D. candidate. The soil-water interface in a disturbed landscape. Completion date: Dec. 2003. Supervisors: Prepas, Ellie E.; Chanasyk, David.

Undergraduate Student Theses

Applewhaite, Chris. 2000. The effect of forest harvest and hill slope position on nutrient availability in boreal forest soils 1999-2000. University of Alberta.

Bouffard, Caroline. 1996. Analyse de la composition et de la structure en taille du zooplancton des lacs de l'Alberta et de la Mauricie (Québec). Université de Montréal.

Decker, Christine. 1998. Gonadal histology and spawning periodicity of female fathead minnows in boreal Alberta. University of Alberta.

Eerkes, Geoff. 1999. Soil phosphorus distribution and adsorption-desorption in cut *vs* uncut aspen boreal forests 1998-1999. University of Alberta.

Hugues, Mireille. 1998. Variation de l'espacement des appendices de filtration de *Daphnia* sp. sous l'effet de l'eutrophisation expérimentale. Université de Montréal.

Lazure-Demers, Geneviève. 1997. Étude du comportement de la surface des filtres en fonction de la taille de *Daphnia* selon leur environnement nutritif. Université de Montréal.

Mohr, Alexandra. 1997. Interactions zooplancton-cyanobactéries : études en enclos limniques. Université de Montréal.

Tiege, Susan. 1996. Determination of single or multiple batch spawning in female fathead minnows. University of Alberta.

Turner, Leah. 1998. Food partitioning within the small-bodied fish communities of four boreal lakes. University of Alberta.

Published and In Press Manuscripts:

Armstrong, N., D. Planas and **E.E. Prepas.** (in press, accepted September 2002). Potential for estimating macrophyte surface area from biomass. Aquatic Botany. (11 ms pp. + 4 tables).

Beaudoin, C.P., W.M. Tonn, E.E. Prepas and **L.I. Wassenaar**. 1999. Individual specialization and trophic adaptability of northern pike (*Esox lucius*): an isotope and dietary analysis. Oecologia. 120:386-396.

Beaudoin, C.P., E.E. Prepas, W.M. Tonn and **L.I. Wassenaar**. 2001. A stable carbon and nitrogen study of lacustrine food webs in Canada's western Boreal Forest. Freshwater Biology. 46:465-477.

Carmosini, N., K.J. Devito and **E.E. Prepas**. (in press, accepted July 2002). Gross nitrogen transformations in harvested and mature aspen-conifer mixed forest soils from the Boreal Plain. Soil Biology and Biochemistry. (8 ms pp. + 2 tables).

Danylchuk, A.J. and **W.M. Tonn**. 2001. Effects of social structure on reproductive activity in male fathead minnows (*Pimephales promelas*). Behavioral Ecology. 12:482-489.

Devito, K.J., I.F. Creed, R.L. Rothwell and **E.E. Prepas**. 2000. Landscape controls on phosphorus loading to boreal lakes: Implications for the potential impacts of forest harvesting. Canadian Journal of Fisheries and Aquatic Sciences. 57:1977-1984.

Eaton, B.R., C. Grekul, and **C.A. Paszkowski**. 1999. An observation of interspecific amplexus between boreal, *Bufo boreas*, and Canadian, *B. hemiophrys*, toads, with a range extension for the boreal toad in central Alberta. Canadian Field-Naturalist. 113: 512-513

Eaton, B.R. and **C.A. Paszkowski**. 1999. Natural history note. *Rana sylvatica* (Wood Frog). Predation. Herpetological Review. 30: 164.

Evans, J.E., E.E. Prepas, K. Devito and **B.G. Kotak**. 2000. Phosphorus dynamics in shallow subsurface waters in an uncut and cut subcatchment of a lake on the Boreal Plain. Canadian Journal of Fisheries and Aquatic Sciences. 57(Suppl. 2): 60-72.

Ghadouani, A. and **B. Pinel-Alloul**. 2002. Phenotypic plasticity in *Daphnia pulicaria* as an adaptation to high biomass of colonial and filamentous cyanobacteria: Experimental evidence. Journal of Plankton Research. 24: 1191-1216.

Ghadouani, A., B. Pinel-Alloul, and **E. E. Prepas**. 2002. (in press, accepted May 2002). Effects of experimentally induced cyanobacterial blooms on crustacean zooplankton communities. Freshwater Biol. (32 ms pp. + 5 tables + 10 fig.).

Hannon, S.J., C.A., Paszkowski, S. Boutin, J. DeGroot, S.E. Macdonald, M. Wheatley and **B.R. Eaton**. (in press, accepted May 2002). Abundance and species composition of amphibians, small mammals and songbirds in riparian forest buffer strips of varying widths in the boreal mixedwood of Alberta. Canadian Journal of Forest Research. 32:1784-1800.

Harper, K.A. and **S.E. Macdonald**. 2001. Structure and composition of riparian boreal forest: new methods for analyzing edge influence. Ecology 82:649-659.

Harper, K. and **S.E. Macdonald**. 2002. The critical values program for assessing edge influence. "Technological Tools" section, Bulletin of the Ecological Society of America. 83: 61-62.

Harper, K.A. and **S.E. Macdonald**. 2002. Structure and composition of edges next to regenerating clear-cuts in the mixed-wood boreal forest. Journal of Vegetation Science. 13:535-546.

Lambert, J.D. and **S.J. Hannon**. 2000. Short-term effects of timber harvest on abundance, territory characteristics, and pairing success of Ovenbirds in riparian buffer strips. Auk. 117:687-698.

Pierre, J., H. Bears and **C.A. Paszkowski**. 2001. Effects of forest harvesting on predation in cavity-nesting waterfowl. Auk. 118(1):224-230.

Pierre, J.P. and **C.A. Paszkowski**. 2000. Changes in aquatic bird densities after forest harvesting in boreal Alberta, Canada. Global Environmental Research. 2:239-240.

Prepas, E.E., B. Pinel-Alloul, D. Planas, G. Méthot, S. Paquet and **S. Reedyk**. 2001. Forest harvest impacts on water quality and aquatic biota on the Boreal Plain: Introduction to the TROLS lake program. Canadian Journal of Fisheries and Aquatic Sciences. 58:421-436.

Students and supervisors presented TROLS material at more than 80 opportunities, including conferences, workshops and invited talks

RESEARCHERS

TROLS included 13 principal investigators who guided research efforts within the various components of the project. Based throughout Canada, the diverse locations and backgrounds of the core researchers brought unique perspectives to the TROLS research efforts.

Dr. Ellie E. Prepas Project Director, Head of Aquatics Research
Lakehead University and University of Alberta

Dr. S. Ellen Macdonald Project Co-Director, Head of Terrestrial Research
University of Alberta

Dr. Stan Boutin
University of Alberta
Dr. Patricia Chambers
National Water Research Institute
Dr. Irena Creed
University of Western Ontario
Dr. Joseph Culp
National Water Research Institute
Dr. Kevin Devito
University of Alberta
Dr. Susan Hannon
University of Alberta
Dr. Cindy Paszkowski
University of Alberta
Dr. Bernadette Pinel-Alloul
Université de Montréal
Dr. Rich Rothwell
University of Alberta, professor emeritus
Dr. William Tonn
University of Alberta
Dr. Fred Wrona
National Water Research Institute

Progress in data analyses was facilitated with the assistance of 3 postdoctoral research associates:

Dr. Chantal Ouimet
Department of Fisheries and Oceans, Lethbridge, Alberta
Dr. Kathy Webster
Department of Biological Sciences, University of Maine at Orono
Dr. Christina Tague
San Diego State University, San Diego, California

Numerous research scientists and land managers from across Canada and within the U.S. contributed to the TROLS project through their involvement in workshops, peer reviews, and site visits. Their feedback and suggestions were greatly appreciated.

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Syncrude Canada Ltd
Vanderwell Contractors (1971) Ltd
Ainsworth Lumber Co. Ltd
CS Resources
RL&L Environmental Services Ltd
Thurber Environmental Consultants Ltd

Provincial Government Partnerships

Alberta Environmental Protection
Alberta Economic Development and Tourism (AED&T)
Province of Québec

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Dr. Daryll Hebert
Encompass Strategic Resources Inc.
Creston, British Columbia

Mr. Ted Szabo
Director, Department of Innovation and Science
Government of Alberta

Source Documents

Written materials used in preparation of this document include only those published in accredited journals. Please see TROLS manuscripts section.

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